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# Integration of AMS and ERDS Measurement Data into NARAC Dispersion Models. FY05 Technology Integration Project Final Report

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# **Integration of AMS and ERDS Measurement Data into NARAC Dispersion Models**

## **FY05 Technology Integration Project Final Report**

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### **Introduction**

Staff from Lawrence Livermore National Laboratory (LLNL), Bechtel Nevada Remote Sensing Laboratory (RSL), and Sandia National Laboratory (SNL) completed the proposed work for the Technology Integration Project titled Integration of AMS and ERDS Measurement Data into NARAC Dispersion Models. The objectives of this project were to develop software to convert Aerial Measurement Survey (AMS) and Emergency Response Data System (ERDS) field measurement data into a standard electronic format for transmission to the National Atmospheric Release Advisory Center (NARAC), and to streamline aspects of the NARAC operational atmospheric dispersion modeling system to quickly process these data for use in generating consequence calculations based on refined, field measurement-based estimates of the source strength.

Although NARAC continues to develop and maintain a state-of-the-art atmospheric dispersion modeling system, model predictions are constrained by the availability of information to properly characterize the source term. During an actual atmospheric release, very little may be known initially about the source material properties, amount, or release time and location. Downwind measurements often provide the best information about the scope and nature of the release. The timely integration of field measurement data with model calculations is an obvious approach toward improving the model consequence predictions. By optimizing these predictions a more accurate representation of the consequences may be provided to (a) predict contamination levels which may be below the detectable limit of sensors, but which may still pose a significant

hazard, (b) determine contamination in areas where measurements have not yet been made, and (c) prioritize the locations of future measurement surveys.

By automating and streamlining much of the related field measurement data processing, these optimized predictions may be provided within a significantly reduced period, and with a reduction in potential errors. The associated operational shortfalls were resolved by completing the following major tasks under this technology integration project:

1. The definition and implementation of a standard Extensible Markup Language (XML) measurement data transmission format,
2. Modification to the NARAC system Graphical User Interface (GUI) to streamline field measurement manipulation and processing within the NARAC system,
3. Modification to the NARAC graphical visualization capabilities to display, filter, and select target measurement data for further processing,
4. Improved access to statistically-oriented comparisons between model calculations and field measurement data aimed at developing a refined source term used to optimize model predictions, and
5. Rewriting of a limited legacy code which performs the calculations necessary to compare model results with field measurement data.

Each of these tasks is discussed below in greater detail. The completed system was successfully used during the Dingo King exercise in August, 2005.

### **Development and Implementation of a Standard Data Transmission Format**

Prior to completion of this project, no standard data file format had been defined for transmission of the AMS and ERDS data to NARAC. Each time data was transmitted to NARAC the data file's format and content required manual analysis or verification. Key information (e.g. the units of measure) often needed verbal confirmation from the data originator. This greatly inhibited the fast, automated data processing required for generating refined model calculations in a timely manner.

Discussions between LLNL, RSL, and SNL staff resulted in the definition of an XML-based standard data transmission file format. XML was chosen, in part, because of its flexibility in allowing for the future definition of additional data fields with minimal impact on existing implementation software. The development of a consistently-used standard format was a critical step in reducing the time required to incorporate these data into the NARAC operational system, while also greatly reducing potential data translation errors.

Appendix A presents a listing of the XML schema developed for the structure of the data transmission file, along with an expanded textual description of the key data elements. Note that the schema presented in Appendix A is a slightly more general structure than that currently in use for AMS/ERDS transmission, as it may also be used for other sources of field measurements. It does however provide the essential format and content used by RSL. The format allows for an "administrative" header section in which file and data format versions, associated event information, and originator identification data may

be defined. This header is then followed by an unlimited number of data measurement elements. Several of these elements are defined as optional, allowing for universal use over a broad spectrum of data sources. The format was reviewed for compatibility with potential future implementation for existing modeling and assessment software tools (e.g. Turbo FRMAC).

Software was written by RSL staff to format the AMS and ERDS data into this standard, and by LLNL staff to read and reformat the data for internal NARAC system use. Data transmission and ingestion tests were successfully completed using data taken primarily from the Capstone series of exercises.

### RSL XML Export Software Development

It should be noted that a major redesign of the Emergency Response Data Systems (ERDS) FRMAC Data Center (DCENT) was initiated in parallel with this project, and is still ongoing. This development will completely redesign the DCENT database, migrating from the legacy networked Paradox DBMS to a Microsoft SQL2000 DBMS. With this effort in mind, RSL made the decision to create an interim program that would have the flexibility to address the current, as well as any future, database until this XML export capability can be integrated into the revised DCENT application.

The “XMLTranslate” program is a custom computer program designed to translate FRMAC field measurement and AMS data into a NARAC-compatible XML-formatted document. The program is “template” driven and works directly with the FRMAC measurement and event tables to obtain the required field measurement data. Templates are small tables that can be directly manipulated by the ERDS staff. A “base” template has been established to ease the creation of scenario specific templates that can be saved and reused by the XMLTranslate program.

The format of the template table and a sample template are shown in Appendix B.

### XMLTranslate



The program is accessed through the following desktop icon:

The program prompts the user for all necessary input as illustrated by the following sequence.

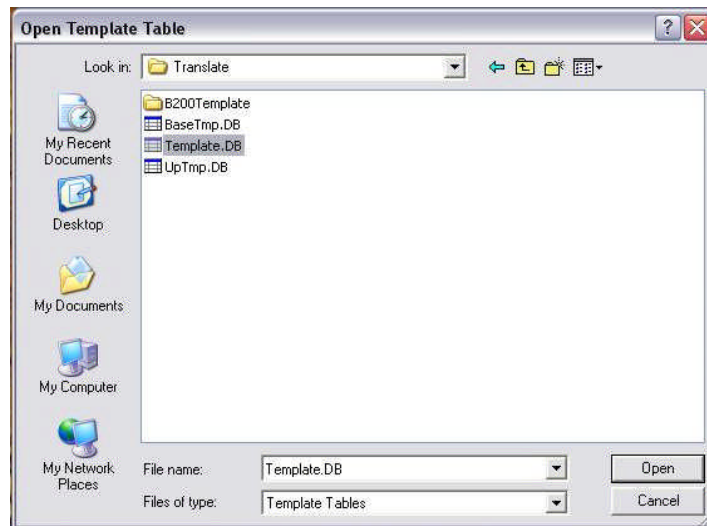
### Time Zone

The local time zone is necessary to generate the NARAC UTC time format. The following dialog allows the user to set the appropriate US time zone. This dialog is to insure that field measurement time is corrected properly even if the database server's time/time zone has not been updated, or is incorrect.



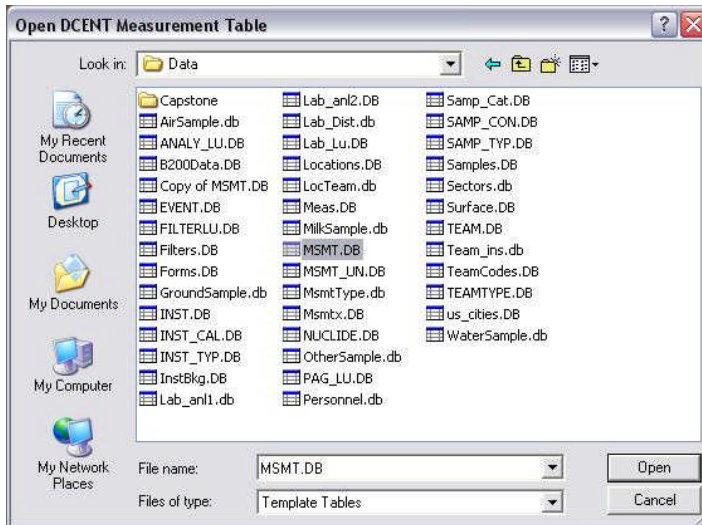
### Template Table

The next prompt is to designate the Template to be used in this transformation.



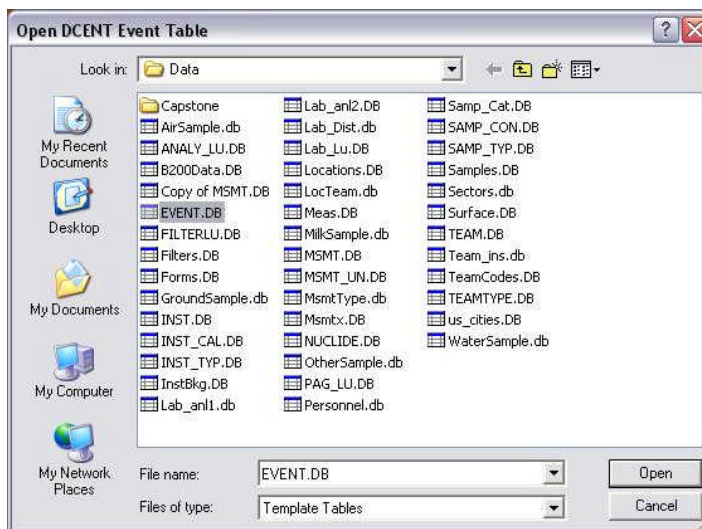
### Measurement Table

The program will then prompt for the measurement table. This table is the source of the actual field measurement data referenced in the template previously selected.



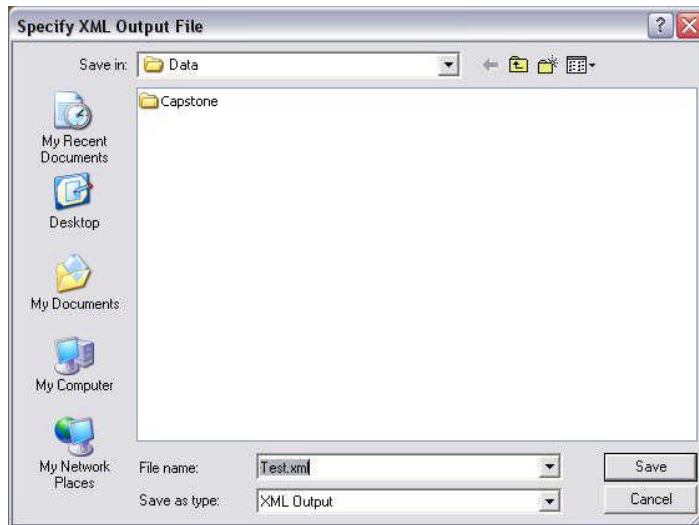
### Event Table

The next prompt is to identify the event table from which the “header” information is to be extracted. Again, this table will be referenced through the template when building the header portion of the XML output file.



### Output File

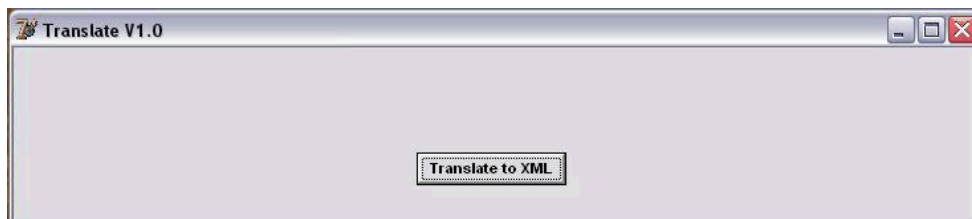
The final prompt is to specify the name and location of the output xml file.



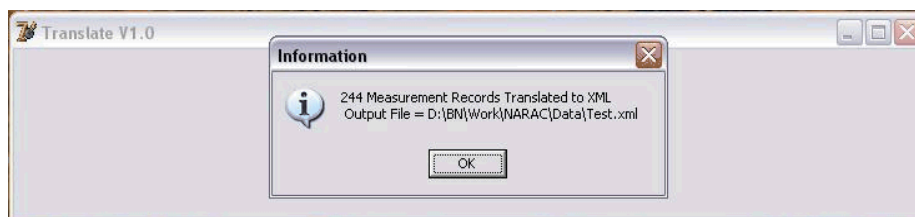
The program will process the template and issue the following information,



followed by the program form. At this point the user may abort the process by simply closing the form, or press the “Translate to XML” button to process the selected tables into xml.



Finally, the program will inform the user of the number of field measurement records processed, and the complete path of the output xml file. Pressing the “OK” button will terminate the program.





An example of the XML output format as applied to the Capstone exercise field measurement data is shown in Appendix C.

#### *Field Measurement Data Upload to NARAC*

The data upload process to NARAC involves establishing a special “event” on the FRMAC web site (FRMAC Web) to contain the XML datasets created by the XMLTranslate program, and uses the administrative upload function of FRMAC Web to move the data onto the web site. NARAC personnel can then log in to FRMAC Web, select the “event” and download any or all datasets contained within the “event”. It should be noted that multiple XML datasets may be created over the course of an exercise or real world emergency response. AMS data is usually handled separately from field ground measurement data, and the field measurement data is uploaded periodically during the course of the emergency response. Only new or modified data is uploaded to NARAC, and some minor changes were made to the legacy data base to allow the program to automatically determine which data should be extracted for upload. This process was utilized during the recent Dingo King exercise.

#### *ERDS DCENT Future Enhancements*

As mention above, RSL considers the XMLTranslate program to be an interim solution. This export capability will be directly integrated into a future revision of the ERDS FRMAC Data Center. The “template” concept will be retained, but will utilize XML documents to control the export rather than the current table-based method, and a user-friendly GUI will be implemented to allow ERDS Data Center staff to easily create and modify these templates in the field. The new DCENT database will be designed to automatically manage the export status of measurement data and handle multiple format exports of the data. This approach will allow the Data Center to custom format and export data to NARAC, as well as any other authorized agency.

#### **Modification of the NARAC System Field Measurements Graphical User Interface**

Once received at NARAC, a series of relatively manual processing steps were required (before the initiation of this TI project) in order to process the field measurement data into the NARAC system and to generate comparisons with the appropriate model calculations. These steps were controlled through access to a series of GUI panels. Based on suggestions from a survey of NARAC Operations staff, several improvements were made to the NARAC GUI panels used to display and process field measurements. These improvements were focused on streamlining the user interaction with the system and improving feedback of the data set characteristics to the operations staff in order to improve analyses of measurements and model predictions.

Initial field measurement data system interaction begins with the importation of the field measurements into an “Event” (i.e. a particular collection of data and model execution results pertaining to a specific atmospheric release), where they can be subsequently

processed and used for comparison with model results. An improvement made to the previous (pre-TI project) system is the capability to create and manipulate multiple groupings (or “Subsets”) of the field measurement data within the Event, providing for greater flexibility and speed in matching appropriate measurements with a given set of model results. Figure 1 shows the new panel developed to create and analyze these data Subsets. The panel follows a previously-used format and interaction used elsewhere in the system for similar types of data manipulation purposes, and replaces the non-standard interactions required by the older field measurement GUI. Selections from this panel allow users to create new data Subsets, or access previously created Subsets. Upon selection of an existing Subset, the Subset’s contents (i.e. list of field measurement records) are displayed in the scrolling region as shown in Figure 1.

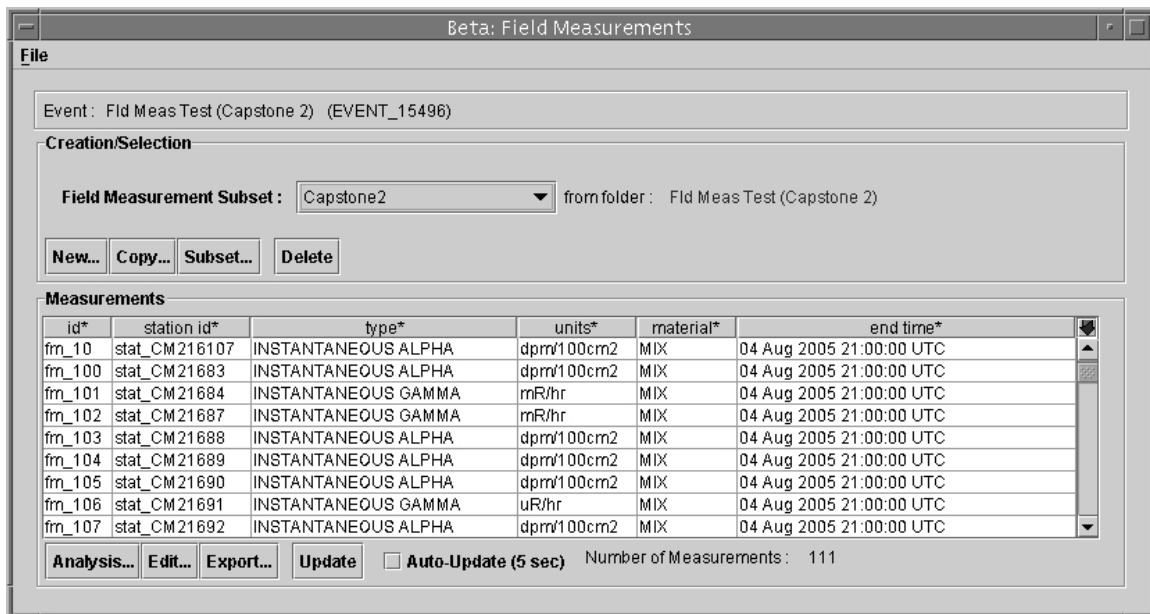


Figure 1

Main GUI panel used for the creation and manipulation of field measurement Subsets. This example shows a summary of the “Capstone 2” Subset contents. Users may add measurements to, delete from, or otherwise edit this Subset through windows accessible from this panel.

Once created, a given Subset may be modified by adding data to, or deleting data from, the existing Subset. This allows for more quickly incorporating additional, or modified, Event-related measurements into previously analyzed Subsets with which the operations staff is already familiar, and eliminate the need to re-edit data already processed into the system Event as the old system required. Figure 2 shows the new panel developed to filter data in an existing Subset based on a user-specified range of data element values. Any combination of fields shown in this panel may be used for data selection.

**Beta: Create Subset**

New Subset Name :

**Search Parameters**

Latitude :

Longitude :

Radius :  m

Materials (one per line) :

Units (comma separated) :

Start Time :

Stop Time :

Material Types	Measurement Types	Exposure Types	Time Types
<input type="checkbox"/> BIOLOGICAL :	<input type="checkbox"/> UNKNOWN :	<input type="checkbox"/> UNKNOWN :	<input type="checkbox"/> AVERAGED :
<input type="checkbox"/> CHEMICAL :	<input type="checkbox"/> ALPHA :	<input type="checkbox"/> AIR :	<input type="checkbox"/> INSTANTANEOUS :
<input type="checkbox"/> CHEMICAL_AGENT :	<input type="checkbox"/> BETA :	<input type="checkbox"/> GROUND :	<input type="checkbox"/> INTEGRATED :
<input type="checkbox"/> RADIOLOGICAL :	<input type="checkbox"/> GAMMA :	<input type="checkbox"/> AIRGROUND :	<input type="checkbox"/> UNKNOWN :
	<input type="checkbox"/> GAMMABETA :		
	<input type="checkbox"/> ACTIVITY :		
	<input type="checkbox"/> MASS :		
	<input type="checkbox"/> TOXIN :		
	<input type="checkbox"/> VIRAL :		
	<input type="checkbox"/> BACTERIOLOGICAL :		

OK Apply Cancel Help

Figure 2

GUI panel used to filter Subset data based on any combination of selected options or values specified in the fields shown above.

Raw data importation into a new or existing Subset is accomplished using the new panel shown in Figure 3. Upon the user specification of the original AMS/ERDS XML data transmission file to import into the event, the system automatically reads and reformats the data based on the developed XML standard. A Raw Analysis section is shown listing the ranges of values found in the data file for key fields of interest (e.g. latitude/longitude of the measurement, measurement value, measurement type (e.g. alpha radiation, gamma radiation, etc.), and so forth as shown in Figure 3. Note that where the string “\*\*\*MULTIPLE\*\*\*” appears, the user may quickly access the list of the various different strings found in the XML file for that data element. This initial textual description of the data values allows the user to begin the familiarization process to better understand the geographic extent and magnitude of the measurement data, and the particular kinds of model products best used for data comparison.

**Beta:**

**Data Source**

Format: NARAC XML

Number of Measurements: 127.0

Original File: /u/kfoster/Capstone2.xml **Reload**

**Raw Analysis**

Lat Range: 36.100185 to 36.46162	Material Type: RADIOLOGICAL
Lon Range: -115.826224 to -115.002352	Material: ***MULTIPLE***
Height Range: 0.0	Meas Type: ***MULTIPLE***
Height Units: m	Exp Type: GROUND
Value Range: 0.0 to 6000	Time Type: INSTANTANEOUS
Value Units: ***MULTIPLE***	Min Time: 04 Aug 2005 08:00:00 UTC
Value Unit Types: ***MULTIPLE***	Max Time: 04 Aug 2005 23:00:00 UTC
Period Range:	Meas. Count: 127

**Controls**

Action: Edit First

**OK Apply Cancel Help**

Figure 3

GUI panel used to import raw field measurement data into the NARAC system. Upon selection of the standard raw data format (“NARAC XML”) and entry of the file name containing the measurement data, value ranges of the key data fields found in the measurement file are presented in the Raw Analysis section. Users may choose to accept the data as is, or to edit the data before completing the Subset creation process.

The raw data can then be edited prior to the creation of a new, or addition to an existing, data Subset. This editing will not normally be required when processing standard XML AMS/ERDS data, but may be required if data in a non-standard format is received. Figure 4 shows a newly developed panel which combines the capabilities of multiple previously-used windows. This new panel allows for the more efficient display, filtering, and data field editing by combining these functions into this single display. The top scrolling region displays each individual field measurement, which may be edited singly or in bulk. The middle section contains numerous data “Mungers” (i.e. data filters) which are used to pare, or otherwise manipulate, the data for specific application to a given set of model results. The Measurement/Column Assignment section is used to assign data columns to the required field measurement fields when importing data in non-standard format (i.e. data other than AMS/ERDS data which is not in the defined XML structure). Allowing access to these related capabilities from this single panel reduces the number of windows previously requiring access to perform these basic functions, thus streamlining the user interaction needed to complete these tasks

Beta:

Header

1	2	3	4	5	6	7	8
Group No.	Station ID	Latitude	Longitude	Height	Height Units	Meas. Label	Measureme
	stat_CM21634	36.22676	-115.022835	0.0	m	CM21634	BETA
	stat_CM21635	36.22676	-115.022835	0.0	m	CM21635	GAMMA
	stat_CM21640	36.22676	-115.022835	0.0	m	CM21640	BETA
	stat_CM21643	36.261375	-115.002352	0.0	m	CM21643	ALPHA
	stat_CM21646	36.261375	-115.002352	0.0	m	CM21646	GAMMA
	stat_CM21648	36.261375	-115.002352	0.0	m	CM21648	BETA
	stat_CM21650	36.220042	-115.025442	0.0	m	CM21650	ALPHA
	stat_CM21652	36.220042	-115.025442	0.0	m	CM21652	GAMMA
	stat_CM21654	36.220042	-115.025442	0.0	m	CM21654	BETA
	stat_Blank109	36.226072	-115.04647	0.0	m	Blank109	ACTIVITY
	stat_Blank76	36.230099	-115.058869	0.0	m	Blank76	ALPHA

Edit All...  
Set Header  
Insert Header  
New...  
Edit...  
Copy...  
Delete

Number of Rows 128

☒ Mungers

Columns : Cut Empties Delete... Insert... Merge... Split... Convert... Scale... Shift... Replace... Fill...  
Rows : Trim Values Insert... Cull... Top... Smart Delete...  
Other : Range... Bounding Box...

☒ Measurement/Column Assignment

Station
Measurement

	Col.	Def. Value
Group No. :	n/a	
Station ID Column :	2	
Latitude :	3	
Longitude :	4	
Height :	5	0.0 m
Height Unit :	6	

OK Apply Cancel Help

Figure 4

Panel used for field measurement editing. Users may manually edit selected data fields for individual measurements or all data records. A large range of filters and data manipulation “Mungers” are available to modify the data. Users may specify raw data file content and structure for non-standard formats using the Measurement/Column Assignment tabs.

Using the panels discussed above, the process to import an AMS/ERDS data file is now a simple 3-step process. Step 1 is to access the data editing panel shown in Figure 3. Step 2 is to enter the name of the XML file containing the data in standard format. This is done by clicking on the filename string shown opposite the **Original File:** label. Upon entry of the appropriate filename the data is read and analyzed to complete the Raw

Analysis section of Figure 3. Step 3 is to optionally review the data ranges displayed in the Raw Analysis section, and then click **OK** or **APPLY** out of the accessed windows.

### **Modification of the NARAC Graphical Visualization of Field Measurements**

Understanding the spatial distribution of field measurement data and interpreting patterns of the measurement magnitudes are key factors in quickly determining the fidelity of the associated model calculations. To assist NARAC operations staff in understanding the spatial nature of the field measurement data, and to offer further options in manipulating the data as part of the process in creating or modifying data Subsets for subsequent comparisons, new capabilities have been added to the graphical visualization process.

The display shown in Figure 5 can be accessed during the data editing/manipulation processes outlined above. Data targeted for incorporation into a field measurement Subset is spatially depicted in a geographic display relative to the source release location (represented by the large “+”). The display may optionally include an underlying geographic map, which (for simplicity of display) was not used here. Field measurement locations are indicated by black circles which are color-filled based on the magnitude of the measurement taken at that location. The plot’s color scheme is shown in the top right corner of the Figure, and gives the measurement magnitude threshold values for each color used in the display. These threshold values are defaulted to illustrate the lowest 10%, 30%, 70%, and 90% of the field measurement distribution of values, but may be edited by the user (as has been done in the Figure) to any desired threshold value. Any of the measurements may be “probed”, as was done for measurement CM216107, to display the window shown in the lower right of the Figure giving detailed information about the selected field measurement. (Note that the use of black-filled circles indicates data less than the lowest threshold value, while white-filled circles indicate measurements of zero.)

Users may select specific measurements for subsequent removal from the data Subset by use of various filter options using this graphical display. Figure 6 shows the panel used to access these filters. Some offer a similar filtering capability to that found in the GUI panels described in the previous section (e.g. filter by measurement magnitude or observation time), while others offer additional options not found elsewhere in the system (e.g. filter by distance from the source release location). This display also allows users to select measurements based on the spatial references depicted in the geographic display by clicking on the individual measurements (i.e. circles) or drawing a polygon around groups of measurements, as has been done in figure 6. Users may refer to the color-filled representations of the measurements to identify values near the high or low end of the measurement distribution for potential elimination from the data Subset. Upon exit from this display, only the remaining (unselected) measurements are made available for further processing into the data Subset.

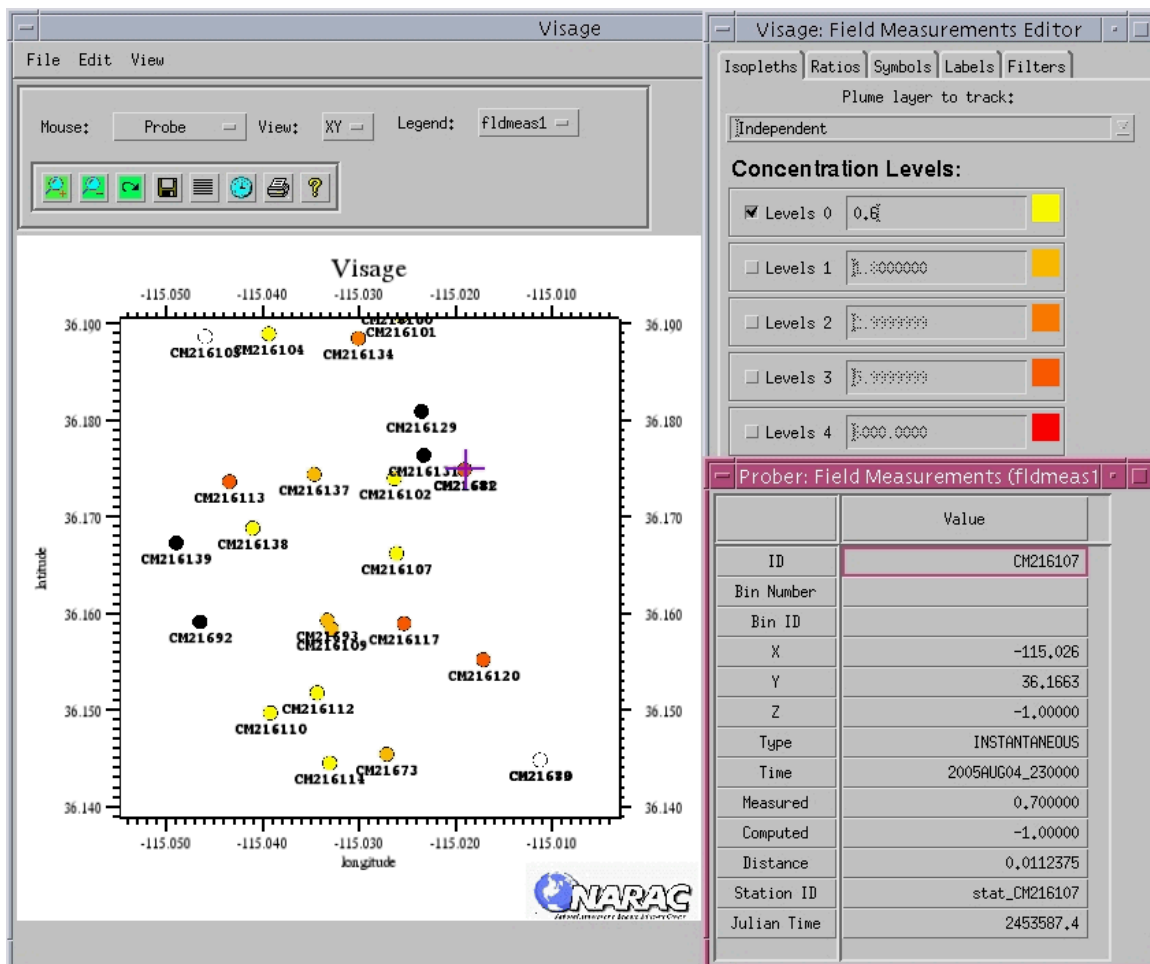


Figure 5

A display of the field measurement spatial distribution using a portion of the Capstone 2 Exercise data Subset is shown on the left. Labeled stations use color coded display to represent the magnitude of the measurement according to the threshold color scale shown in the top right. Black circles indicate measurement values less than the lowest threshold level (0.6 in this case). White-filled circles indicate measurement values of zero. The source release location is denoted by the large magenta "+". Individual measurements may be probed for additional details, as shown in the lower right for the station labeled with the identifier "CM216107" (the station colored yellow near the center of the geographic spatial display).

Visualization improvements were not limited to those relevant to creation of data Subsets. New graphical displays of the comparisons between the measurements and model results were also implemented. Figure 7 shows a display similar to Figure 5. However the geographic display area now shows appropriate model-calculated concentration contours associated with the measurement locations, which are again represented by the black circles, but now the color fill represents the magnitude thresholds of the measurement/calculation ratios formed by pairing each measurement with the model calculated value matched in space and time. This display will allow users to quickly judge the general areas in which the model under- or over-predicts, and where

The screenshot shows the Visage Field Measurements Editor software. The main plot area displays a map with latitude on the y-axis (ranging from 36.140 to 36.190) and longitude on the x-axis (ranging from -115.050 to -115.010). Numerous measurement points are plotted, each labeled with a unique identifier such as CH216104, CH216134, CH216129, CH216137, CH216102, CH216138, CH216107, CH216117, CH216120, CH216110, CH216112, CH216114, CH216173, CH216109, CH216139, CH216113, CH216101, CH216131, and CH216105. A pink polygon is drawn around a cluster of points in the lower right quadrant of the plot. The right-hand panel contains several configuration sections: 'Measurement Time' is set to 2005AUG04\_080000; 'Measurement Magnitude' has a range from 0.00000 to 6000.00; 'Source Distance' has a range from 0.00000 to 0.807462; 'Location Based Sampler Exclusion' has two radio buttons, with 'Draw a polyline enclosing the samplers' selected; 'Sampler selection' includes buttons for 'Start', 'Finish', 'Clear', and 'Info'; and 'Total of 111 measurements' is displayed with a 'Save' button below it. The bottom right corner of the window features 'OK', 'Apply', and 'Close' buttons.

Using the panel shown on the right, the user may filter the data by measurement time, magnitude, or distance from the source location. Measurements may also be eliminated from the data Subset by interactively selecting a series of individual stations or selecting a group of polygon-enclosed stations (as was done above). The color-coded data and their position relative to the source may assist the user in paring the less significant measurements from large data sets.



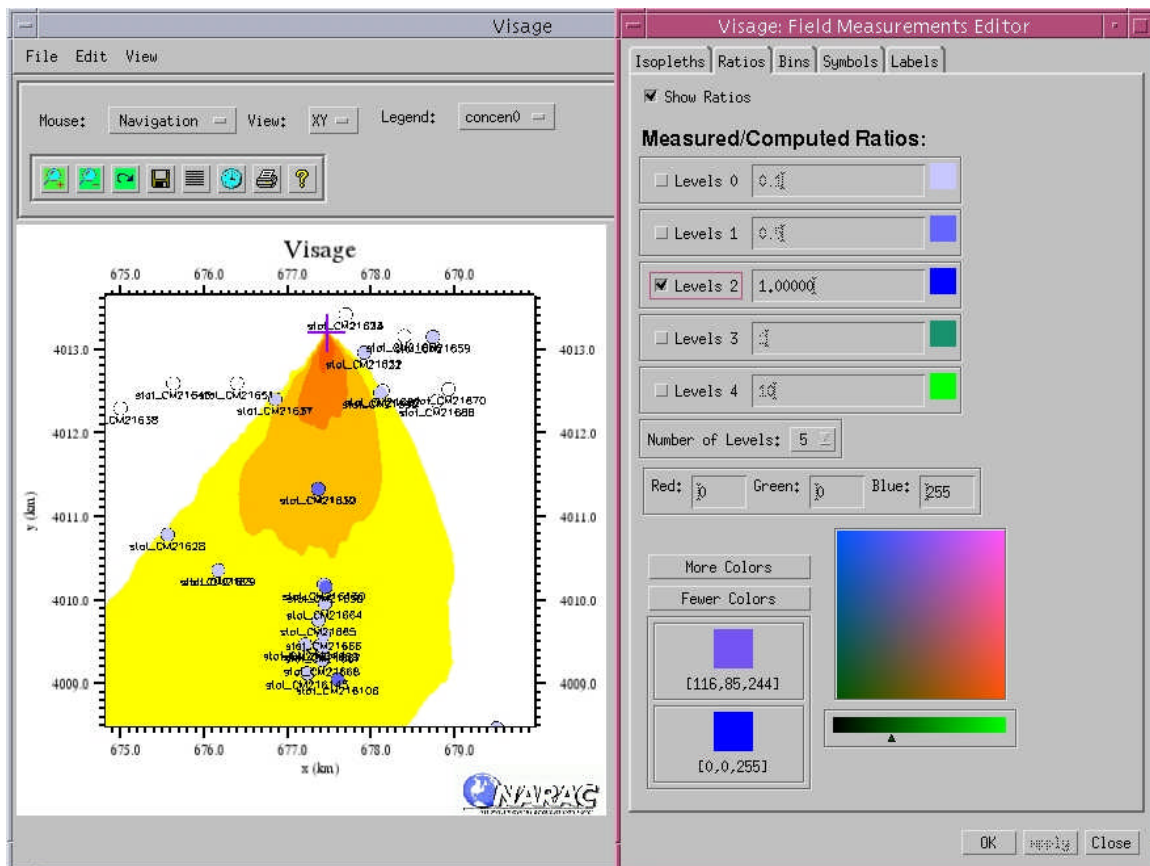


Figure 7

Measured/Computed ratios may be displayed over the model-calculated contamination contours to aid judgment of overall model performance. The ratio color scheme is shown in the upper right. As is seen in this example, the predominance of bluish-filled circles (i.e. ratios less than 1.0) indicates a general over-prediction by the model. (Note that station textual labels may be hidden or re-sized to allow for additional viewing clarity.)

### Improved Access to Statistical Comparisons

To further aid NARAC operations staff in determining the statistical performance of the comparison of the model results to the measurement data, improved access to a widely distributed statistical model calculation-to-measurement comparison code was implemented. The BOOT code (Hanna, et al.1993) generates basic statistical measures of the measurement-calculation residuals, such as fractional bias, fractional scatter, correlation coefficient, ratio analyses, etc. Figure 8 shows a pre-existing interface to this code which not only allows the execution of the statistical comparison code, but also display of its results and of statistically-oriented graphics such as scatter and Q-Q plots. As part of this project, automated data links were established to make this interface much more easily accessible to the NARAC Operations staff.

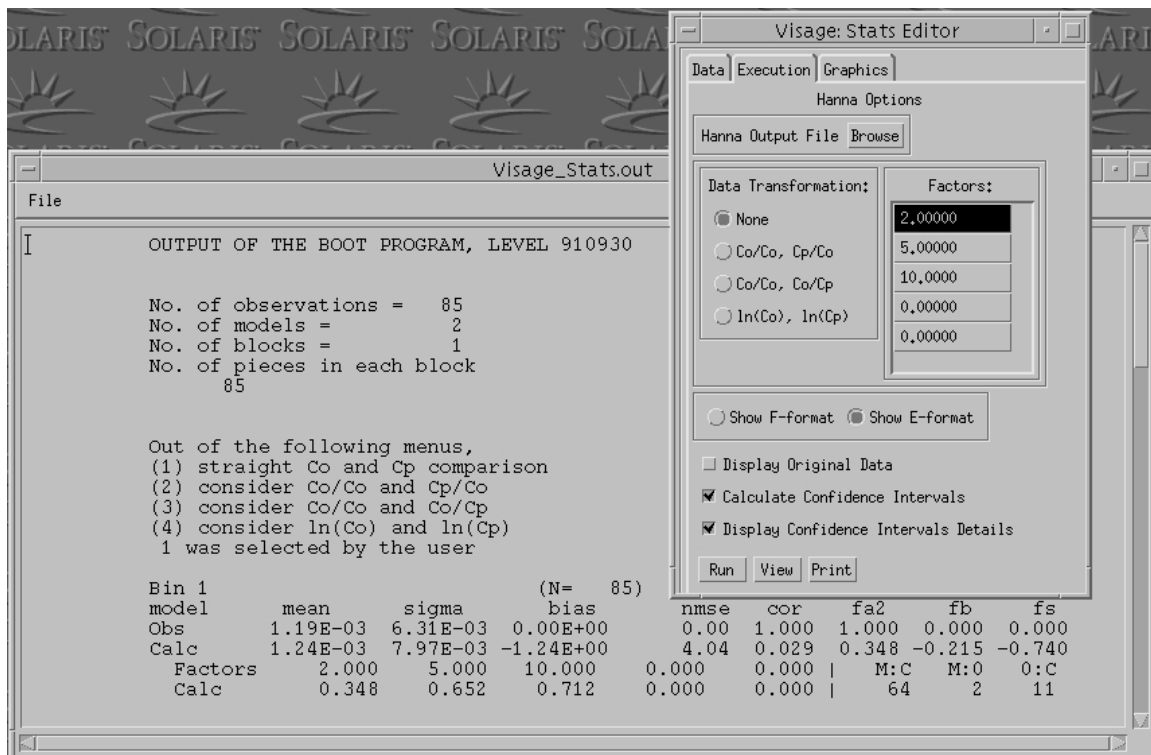


Figure 8

An example of the GUI panels used to access control for the BOOT statistical code and the display of the code's statistical results. (Note that these sample results are not related to the Capstone data set used in previous displays.)

In addition, a new statistical graphical display was made available to the users from this interface. Figure 9 shows this new ratio distribution plot which combines a histogram of the magnitude of the measurement/calculation ratios with a display of the cumulative distribution of the ratios. Again, users may use this type of display to objectively judge relative model performance across the entire distribution of measurement data.

The statistical results presented by the various displays illustrated above can then be used to make subsequent modifications to model input parameters in order to generate a set of results which better match the measurement data.

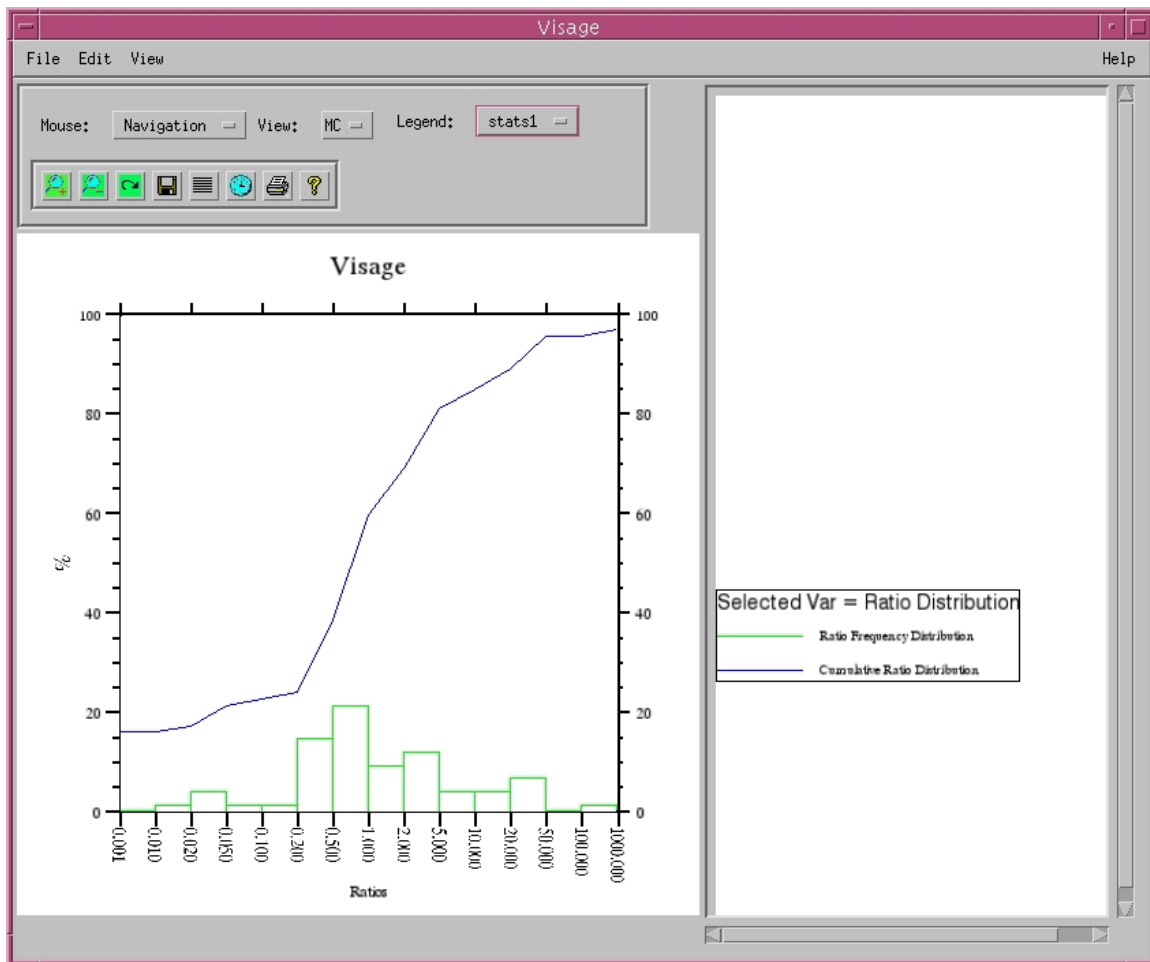


Figure 9

A new statistically-oriented graphical plot, now available, which shows a histogram of the measured/computed ratio frequency distribution, along with the cumulative ratio distribution. Note that this particular set of results shows a relative balance between model over- and under-prediction, and generally good agreement with a large fraction of the ratios within a factor of 5 (i.e. ratios ranging from 0.2 to 5.0).

### **Rewriting of Data Pairing Code**

Previous statistical analyses of model performance were hampered by the required use of legacy code which paired each field measurement with the appropriate interpolated model calculated value. This Fortran code was used in the previous generation of the NARAC system architecture and emergency response system. Its antiquated methodology placed artificial limitations on system capabilities (e.g. the number of measurements for a single execution was limited, lengths of station identifiers were limited, etc.). In addition to this, much of the source code implemented obsolete capabilities and was difficult to maintain within the current system environment.

This code was rewritten in C++ to better integrate into NARAC's current architecture. During this conversion, old unused capability and operational limitations were eliminated. As a result, operational performance of the code was increased while also allowing for a more efficient implementation of future enhancements to provide additional flexibility and new analysis methods.

### **Potential Future Work**

The completion of this project has laid the groundwork for additional development efforts. One area of further potential work is in data communications which currently requires the manual step of downloading the XML measurements file via the FRMAC Web interface (and the related manual download of NARAC products via the NARAC Web interface). These processes would become more efficient if the respective systems allowed for the automated distribution of data products to select targeted facilities (e.g. data products could be "pushed" to those using the data, instead of requiring the users to "pull" the data, as it is currently done). Also, when identified, advanced data-driven methodologies for plume model-to-measurement comparison and refinement can now be more easily implemented within the system, and take advantage of the data processing and analysis methods and displays created under this project.

## References

Hanna, S.R., D.G. Strimaitis, J.C. Chang (1993); Hazard Response Modeling Uncertainty (A Quantitative Method) Vol I, User's Guide for Software for Evaluating Hazardous Gas Dispersion Models, Engineering & Services Laboratory, Tyndall Air Force Base, Florida, ESL-TR-91-28 (available from Defense Technical Information Center)

## APPENDIX A

### Extensible Markup Language (XML) Data Transmission Format Schema

The following schema is a general guide to the current NARAC XML field measurement data transmission structure. It is expected that modifications to this will be required as additional types of field measurement data is processed. The list of data elements which follow the schema gives an alternative description of the file contents, and explains some additional restrictions placed specifically upon the AMS/ERDS data format.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema elementFormDefault="qualified"
  targetNamespace="http://narac.llnl.gov"
  xsi:schemaLocation="http://narac.llnl.gov BasicSchema.xsd"
  xml:lang="en" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:ns2="http://www.w3.org/1999/xhtml"
  xmlns:narac="http://narac.llnl.gov"
  xmlns:hfp="http://www.w3.org/2001/XMLSchema-hasFacetAndProperty">
  <xs:include id="narac" schemaLocation="BasicSchema.xsd"/>

  <xs:simpleType name="samplingType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="AVERAGED"/>
      <xs:enumeration value="INSTANTANEOUS"/>
      <xs:enumeration value="INTEGRATED"/>
      <xs:enumeration value="OTHER"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="fieldOfViewType">
    <xs:restriction base="xs:token">
      <xs:enumeration value="AREA"/>
      <xs:enumeration value="VOLUME"/>
    </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="measurementType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="ALPHA"/>
      <xs:enumeration value="BETA"/>
      <xs:enumeration value="GAMMA"/>
      <xs:enumeration value="GAMMABETA"/>
      <xs:enumeration value="ACTIVITY"/>
      <xs:enumeration value="MASS"/>
      <xs:enumeration value="TOXIN"/>
    </xs:restriction>
  </xs:simpleType>
```

```
    <xs:enumeration value="VIRAL"/>
    <xs:enumeration value="BACT"/>
    <xs:enumeration value="UNKNOWN"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="exposureType">
  <xs:restriction base="xs:token">
    <xs:enumeration value="GROUND"/>
    <xs:enumeration value="AIR"/>
    <xs:enumeration value="AIRGROUND"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="qualityType">
  <xs:restriction base="xs:token">
    <xs:enumeration value="RAW"/>
    <xs:enumeration value="ASSESSED"/>
    <xs:enumeration value="HOLD"/>
    <xs:enumeration value="RELEASED"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="materialType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="BIOLOGICAL"/>
    <xs:enumeration value="CHEMICAL - AGENT"/>
    <xs:enumeration value="CHEMICAL - INDUSTRIAL"/>
    <xs:enumeration value="RADIOLOGICAL"/>
    <xs:enumeration value="RADIOLOGICAL - HYBRID"/>
    <xs:enumeration value="MIXTURE"/>
    <xs:enumeration value="OTHER"/>
    <xs:enumeration value="Nuclide"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="dayUnit">
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="1"/>
    <xs:maxInclusive value="31"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="monthUnit">
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="1"/>
```

```
<xs:maxInclusive value="12"/>
</xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="yearUnit">
  <xs:restriction base="xs:integer">
    <xs:pattern value="[0-9][0-9][0-9][0-9]"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="hourUnit">
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="0"/>
    <xs:maxInclusive value="24"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="minuteUnit">
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="0"/>
    <xs:maxInclusive value="59"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="secondUnit">
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="0"/>
    <xs:maxInclusive value="59"/>
  </xs:restriction>
</xs:simpleType>
```

```
<xs:simpleType name="timezoneUnit">
  <xs:annotation>
    <xs:documentation>
      Time zone is usually UTC in all products. Only a product that
      has been modified will have any other time zone. Format of dates
      should be driven by displaying software. Other time zones included
      for convenience.
    </xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string">
    <xs:enumeration value="UTC"/>
    <xs:enumeration value="PDT"/>
    <xs:enumeration value="PST"/>
    <xs:enumeration value="MDT"/>
    <xs:enumeration value="MST"/>
  </xs:restriction>
</xs:simpleType>
```



```

    <xs:enumeration value="CDT"/>
    <xs:enumeration value="CST"/>
    <xs:enumeration value="EDT"/>
    <xs:enumeration value="EST"/>
    <xs:enumeration value="Pacific"/>
    <xs:enumeration value="Mountain"/>
    <xs:enumeration value="Central"/>
    <xs:enumeration value="Eastern"/>
  </xs:restriction>
</xs:simpleType>

<xs:complexType name="dateTime">
  <xs:attribute name="day" type="dayUnit"/>
  <xs:attribute name="month" type="monthUnit"/>
  <xs:attribute name="year" type="yearUnit"/>
  <xs:attribute name="hour" type="hourUnit"/>
  <xs:attribute name="minute" type="minuteUnit"/>
  <xs:attribute name="second" type="secondUnit"/>
  <xs:attribute name="tz" type="timezoneUnit"/>
</xs:complexType>

<xs:element name="measurementSet">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="header">
        <xs:complexType>
          <xs:sequence>
            <xs:element minOccurs="0" name="formatVersion" type="xs:token"/>
            <xs:element minOccurs="0" name="originator" type="xs:token"/>
            <xs:element minOccurs="0" name="eventName" type="xs:token"/>
            <xs:element minOccurs="0" name="eventType" type="xs:string"/>
            <xs:element minOccurs="0" name="updateVersion" type="xs:token"/>
            <xs:element name="createTime" type="narc:dateTime">
              <xs:annotation>
                <xs:documentation>When this set was created (e.g., when the
                  XML file was created) - not when the measurements were
                  collected.
                </xs:documentation>
              </xs:annotation>
            </xs:element>
            <xs:element minOccurs="0" name="sourceLocation">
              <xs:annotation>
                <xs:documentation>If known, the location of the material
                  released. </xs:documentation>
              </xs:annotation>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>

```

```

<xs:complexType>
  <xs:sequence>
    <xs:element name="polygon">
      <xs:complexType>
        <xs:attribute name="points" type="xs:token">
          <xs:annotation>
            <xs:documentation>x,y space delimited
              values</xs:documentation>
          </xs:annotation>
        </xs:attribute>
        <xs:anyAttribute processContents="lax"/>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
  <xs:anyAttribute processContents="lax"/>
</xs:complexType>
</xs:element>

<xs:element maxOccurs="unbounded" minOccurs="0" name="measurement">
  <xs:complexType>
    <xs:sequence>
      <xs:element minOccurs="0" name="measurementLabel type="xs:token">
        <xs:annotation>
          <xs:documentation>Labels are indexes into a measurement file.
            Therefore, if a label is provided, the value must
            be unique within the file. </xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element minOccurs="0" name="dataSource" type="xs:token"/>
      <xs:element name="location">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="polygon">
              <xs:complexType>
                <xs:attribute name="points" type="xs:token"/>
                <xs:anyAttribute processContents="lax"/>
              </xs:complexType>
            </xs:element>
          </xs:sequence>
          <xs:anyAttribute processContents="lax"/>
        </xs:complexType>
      </xs:element>
      <xs:element name="endTime" type="narc:date"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>

```

```

<xs:element minOccurs="0" name="period">
  <xs:complexType>
    <xs:annotation>
      <xs:documentation>For INSTANTANEOUS measurements, the period
        is not required.</xs:documentation>
    </xs:annotation>
    <xs:attribute default="TimeDuration" name="unitType" type="xs:token"/>
    <xs:attribute name="units" type="narc:durationTimeUnit"/>
    <xs:attribute name="value" type="xs:double"/>
  </xs:complexType>
</xs:element>
<xs:element name="measurementTimeType" type="narc:samplingType"/>
<xs:element name="materialType" type="narc:materialType"/>
<xs:element name="exposureType" type="narc:exposureType"/>
<xs:element name="measurementType" type="narc:measurementType"/>
<xs:element name="materialName" type="xs:token"/>
<xs:element minOccurs="0" name="valueHeight">
  <xs:complexType>
    <xs:attribute default="Distance" name="unitType" type="xs:token"/>
    <xs:attribute name="units" type="xs:token"/>
    <xs:attribute name="value" type="xs:double"/>
  </xs:complexType>
</xs:element>
<xs:element name="value">
  <xs:complexType>
    <xs:attribute name="value" type="xs:double"/>
  </xs:complexType>
</xs:element>
<xs:element minOccurs="0" name="units" type="xs:token"/>
<xs:element minOccurs="0" name="isBackground">
  <xs:complexType>
    <xs:attribute name="value" type="xs:boolean"/>
  </xs:complexType>
</xs:element>
<xs:element minOccurs="0" name="qualityControl" type="narc:qualityType"/>
<xs:element minOccurs="0" name="instrumentType" type="xs:token"/>
<xs:element minOccurs="0" name="instrumentEfficiency">
  <xs:complexType>
    <xs:attribute name="value" type="xs:double"/>
  </xs:complexType>
</xs:element>
<xs:element minOccurs="0" name="fieldOfView">
  <xs:complexType>
    <xs:attribute name="unitType" type="xs:token"/>
    <xs:attribute name="units" type="xs:token"/>
    <xs:attribute name="value" type="xs:double"/>
  </xs:complexType>
</xs:element>

```

```

        </xs:complexType>
      </xs:element>
      <xs:element minOccurs="0" name="teamID" type="xs:token"/>
      <xs:element maxOccurs="unbounded" minOccurs="0" name="remarks" type="xs:token"/>
    </xs:sequence>
    <xs:attribute default="false" name="simulated" type="xs:boolean"/>
  </xs:complexType>
</xs:element>
</xs:sequence>
<xs:attribute name="version" type="xs:token"/>
</xs:complexType>
</xs:element>
</xs:schema>

```

The AMS/ERDS-specific implementation has some minor differences from the schema shown above (e.g. many elements described as optional in the schema are in fact required for AMS/ERDS data, some enumeration values are not allowed, etc.). The XML elements, as implemented specifically for the AMS/ERDS data transmission, are further described as:

#### **createTime**

Time element indicating the time at which this data file was created. Attributes are “year” (4-digit year), “month” (1-12), “day” (1-31), “hour” (0-23), “minute” (minute: 0-59), “second” (second: 0-59), and “tz” (time zone: preferred zone is “UTC”).

#### **dataSource**

Required string element identifying the original organization or system responsible for measurement of these data (e.g. “AMS”, “STATE”, “RAP”, etc.). Additional strings to be agreed upon.

#### **endTime**

Required time element indicating the time (or ending time of the measurement period for time-averaged or time-integrated measurements) at which this measurement was taken. Attributes are “year” (4-digit year), “month” (1-12), “day” (1-31), “hour” (0-23), “minute” (minute: 0-59), “second” (second: 0-59), and “tz” (time zone: preferred zone is “UTC”).

#### **eventName**

Optional string element identifying the exercise or event with which these data are associated.

#### **eventType**

Optional string element (one of “REAL” or “EXERCISE”) which characterizes the nature of these data.

**exposureType**

Required string element which categorizes the measurement based on the location of the material producing the measurement as one of “AIR”, “GROUND”, or “AIRGROUND” (if material being measured is both in the air and on the ground).

**fieldOfView**

Optional element which identifies the spatial domain over which the measurement was taken (i.e. the area or volume in which the material can be found during the measurement period). If used, its value may be reported either as an area or volume as specified by the required attribute “unitType” which is set to “Area” or “Volume”. Additional required attributes are “value” (holding the numeric value in the indicated units) and “units” set to one of “cm2”, “m2”, “km2”, “in2”, “ft2”, “mi2” for Area, and “cm3”, “m3”, “km3”, “in3”, “ft3”, “mi3” for Volume.

**formatVersion**

Optional string. Same as version attribute.

**header**

Required structure (one per measurementSet) holding elements related to the set or associated event.

**instrumentEfficiency**

Optional double precision element identifying the measurement efficiency of the instrument recording the measured value.

**instrumentType**

Optional string element identifying the instrument, or platform, taking the measurement (e.g. “VIOLINIST”, “B200 AIRCRAFT”, “HELICOPTER”, etc.). Exact strings to be determined.

**isBackground**

Optional Boolean element specifying if the measurement is representative of pre-release background levels. If used, a single attribute of “value” should be set to 0 (not representative of background) or 1 (representative of background).

**location**

Required structure containing a single polygon element (which identifies the longitude and latitude representative of this measurement) and having an optional “name” attribute used to hold an associated location label (e.g. “4<sup>th</sup> & Oak St.”).

**materialName**

Required string element identifying the single material (e.g. radionuclide given as “CS-137”, or “SR-90”, or “PU-239”, etc) being measured, or “MIX” if more than material/nuclide in the measurement. Allow “UNKNOWN”. Note: if analysis of

the measurement sample yields data on more than one radionuclide, separate measurement records should be created for each of the materials.

**materialType**

Required string element which categorizes the measurement based on the characteristics of the material being measured. For AMS/ERDS, this string will be “RADIOLOGICAL”.

**measurement**

Structure (zero or more per file) holding elements related to individual measured values.

**measurementLabel**

Required string element uniquely identifying the measurement within the file...preferably uniquely identifying the measurement across all files for a given event.

**measurementSet**

Required element containing a header element and 0 or more measurement elements. It has the attribute “version” which is set to the current XML format version number. It must have the following namespace declarations:

```
xmlns="http://narac.llnl.gov"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:ns2="http://www.w3.org/1999/xhtml"
xmlns:narac="http://narac.llnl.gov"
xmlns:hfp="http://www.w3.org/2001/XMLSchema-hasFacetAndProperty">
```

**measurementTimeType**

Required string element which categorizes the measurement based on its characteristics of being one of “INSTANTANEOUS”, “AVERAGED”, or “INTEGRATED”.

**measurementType**

Required string element which categorizes the measurement based on the characteristics of what is actually being measured (e.g. type of radiation, mass, etc) as one of “ALPHA”, “BETA”, “GAMMA”, “GAMMABETA” (if both types of radiation are included), “ACTIVITY”, “MASS”, plus strings related to biological measurements which are not relevant for AMS/ERDS data.

**originator**

Optional string element describing the organization that distributed the measurementSet. There can be multiples to capture the chain of organizations involved in the set’s distribution.

**period**

Optional duration element identifying the duration over which a time-averaged or time-integrated measured value was taken. If used, the required attributes are “unitType” set to “TimeDuration”, “units” set to one of “s” (seconds), “min” (minutes), “hr” (hours), or “d” (days), and “value” set to the numeric duration in the indicated units.

**polygon**

Standard location element which contains signed decimal longitude and latitude point(s). For example longitudes expressed as -123.1234, + = Eastern, - = Western; and latitudes expressed as +40.1234, + = Northern, - = Southern. This element is used in two places in the file.

The first use is in the sourceLocation structure and contains the “points” attribute set equal to the longitude and latitude values and the “name” attribute set to “lonlat”. This element gives the longitude and latitude of a source from which the measured material is being emitted.

The second use is in the measurement’s location structure and contains the “points” attribute set equal to the longitude and latitude values and the “name” attribute set to “lonlat”. This required element gives the longitude and latitude representative of the measurement.

**qualityControl**

Optional string element expressing the analysis stage or current disposition of the measurement (e.g. “HOLD”, “RAW”, “ASSESSED”, etc.). Exact strings yet to be determined.

**remarks**

Optional string element used to record any text to be associated with the measurement.

**sourceLocation**

Optional structure(s) containing a single polygon element (which identifies the longitude and latitude representative of the location of the source(s) of the measured material(s)) and having an optional “name” attribute used to hold an associated location label (e.g. “4<sup>th</sup> & Oak St.”).

**teamId**

Optional string element identifying the measurement team recording the measurement.

**units**

Required string element giving the units associated with the “value” element as one of:

**Activity/Area\***

Ci/cm2	uCi/cm2	pCi/cm2	dpm/cm2
Ci/m2	uCi/m2	pCi/m2	dpm/m2
Ci/in2	uCi/in2	pCi/in2	dpm/in2

\*Units also available for Becquerels

**Activity/Volume\***

Ci/cm3	uCi/cm3	pCi/cm3	dpm/cm3
Ci/m3	uCi/m3	pCi/m3	dpm/m3
Ci/in3	uCi/in3	pCi/in3	dpm/in3

\*Units also available for Becquerels

**Dose**

Rad	mRad	uRad
Rem	mRem	uRem
R	mR	uR
Sv	mSv	uSv

**Dose Rate**

Rad/hr	mRad/hr	uRad/hr
Rem/hr	mRem/hr	uRem/hr
R/hr	mR/hr	uR/hr
Sv/hr	mSv/hr	uSv/hr

Other units available for Integrated Air Concentration, Mass, Mass/Volume, Radioactivity, etc. Can be supplied if needed.

**updateVersion**

Optional string element identifying the version of this file in the sequence of data files supplied for a given event. It is assumed that subsequent file versions in a particular sequence will correct or augment earlier data files in the sequence. Unmodified data will not be repeated in subsequent versions.

**value**

Required double precision element giving the numeric value of the measurement in the units given in the “units” element. The value reported here is assumed to contain background levels (in addition to any above background levels).

**valueHeight**

Optional distance element identifying the height above ground level of the material when it was measured. For example, in the absence of a plume, AMS measurements would specify the height as “0” (i.e. material is on the surface). If used, the required attributes are “unitType” set to “Distance”, “units” set to one of “cm” (centimeters), “m” (meters), “km” (kilometers), “in” (inches), “ft” (feet), “mi” (miles), and “value” set to the height in the indicated units.



**version**

Required string attribute to the measurementSet element which identifies the version of this XML file structure and content. Used in software to identify expected file format and content.

## APPENDIX B

### RSL XMLTranslate Program Template Format

TemplateID	integer	Identifies this template
Rec	integer	Identifies the location of the tag in the output xml document. (1 = Header, 2 = Measurement)
Order	integer	Indicate the order of the tag within the Location established in Rec, above.
Tag	string	The name of the tag.
Type	integer	The tag type, where: 1 = stringType 2 = locationType 3 = timeDateType 4 = unitValueType 5 = valueType 6 = boolType
V1	string	Value 1 as determined by Src <i>Note: "*" indicates unused.</i>
V2	string	Value 2, same as above
V3	string	Value 3, same as above
Src	integer	0 = Skip (do not include) this tag 1 = Val(s) are literal string constants 2 = Val(s) contains DB field names

## Sample Template

TemplateID	Rec	Order	Tag	Type	V1	V2	V3	Src
1	1	1	formatVersion	1	1.1	*	*	0
1	1	2	originator	1	FRMAC	*	*	1
1	1	3	eventName	1	EventTitle	*	*	2
1	1	4	eventType	1	EventType	*	*	2
1	1	5	updateVersion	1	1.0	*	*	1
1	1	6	createTime	3	*	*	UTC	1
1	1	7	sourceLocation	2	*	Longitude	Latitude	2
1	2	1	measurementLabel	1	LogID	*	*	2
1	2	2	dataSource	1	FRMAC	*	*	1
1	2	3	location	2	Location	Longitude	Latitude	2
1	2	4	endTime	3	MeasDate	MeasTime	UTC	2
1	2	5	period	4	TimeDuration	sec	MeasDuration	0
1	2	6	measurementTimeType	1	INSTANTANEOUS	*	*	1
1	2	7	materialType	1	RADIOLOGICAL	*	*	1
1	2	8	exposureType	1	GROUND	*	*	1
1	2	9	measurementType	1	MeasType	*	*	2
1	2	10	materialName	1	MIX	*	*	1
1	2	11	valueHeight	4	Distance	m	0.0	1
1	2	12	value	5	MeasValue	*	*	2
1	2	13	units	1	MeasUnits	*	*	2
1	2	14	isBackground	6	*	*	*	0
1	2	15	qualityControl	1	RAW	*	*	1
1	2	16	instrumentType	1	IntrumentType	*	*	2
1	2	17	instrumentEfficiency	5	*	*	*	0
1	2	18	fieldOfView	4	*	*	*	0
1	2	19	teamId	1	Team	*	*	2
1	2	20	remarks	1	*	*	*	0

## APPENDIX C

### Example XMLTranslate Program XML-Formatted Data Output

```
<?xml version="1.0" encoding="UTF-8" ?>
- <measurementSet VERSION="1.1" xmlns="http://narac.llnl.gov"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:ns2="http://www.w3.org/1999/xhtml"
  xmlns:ns="http://naracweb.llnl.gov" xmlns:narac="http://narac.llnl.gov"
  xmlns:hfp="http://www.w3.org/2001/XMLSchema-hasFacetAndProperty">
- <header>
  <originator>FRMAC</originator>
  <eventName>Capstone Drill</eventName>
  <eventType>EXERCISE</eventType>
  <updateVersion>1.1</updateVersion>
  <createTime year="2005" month="6" day="23" hour="22" minute="34" second="11" tz="UTC" />
- <sourceLocation>
  <polygon points="-80.2464,27.3486" name="lonlat" />
  </sourceLocation>
  </header>
- <measurement>
  <measurementLabel>CS77175</measurementLabel>
  <dataSource>FRMAC</dataSource>
- <location name="SANDHILL and EDISON">
  <polygon points="-80.163586,27.3782" name="lonlat" />
  </location>
  <endTime year="2005" month="3" day="18" hour="18" minute="53" second="0" tz="UTC" />
  <measurementTimeType>INSTANTANEOUS</measurementTimeType>
  <materialType>RADIOLOGICAL</materialType>
  <exposureType>GROUND</exposureType>
  <measurementType>BETA</measurementType>
  <materialName>MIX</materialName>
  <valueHeight unitType="Distance" UNITS="m" VALUE="0.0" />
  <value VALUE="0" />
  <units>dpm/100cm2</units>
  <qualityControl>RAW</qualityControl>
  <instrumentType>BP-100</instrumentType>
  <teamId>Bravo</teamId>
  </measurement>
- <measurement>
{ ... measurement records content }
  </measurement>
{ ... Additional measurement records }
</measurementSet>
```